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ATTRACTION OF FEMALE ORIENTAL FRUIT FLY, *Bactrocera dorsalis*, TO VOLATILE SEMIOCHEMICALS FROM LEAVES AND EXTRACTS OF A NONHOST PLANT, PANAX (*Polyscias guilfoylei*) IN LABORATORY AND OLFACTOMETER ASSAYS

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Abstract—Fresh whole leaves and solvent–water leaf extracts of the hedgerow plant panax, *Polyscias guilfoylei* (Bull), were tested for their attractiveness to male and female Oriental fruit flies, *Bactrocera dorsalis*, in laboratory flight tunnel and cage olfactometer bioassays. Fresh mature whole panax leaves were found to be attractive to mated female oriental fruit flies in the flight tunnel. Response of males and virgin females was low and in most instances not significantly different from controls. Attraction of mated female flies to the layers resulting from a methylene chloride–water partition or a hexane–water partition of freshly ground leaves using small McPhail traps was greatest in the methylene chloride fraction. When methylene chloride and water layers were tested competitively in a multiple-choice rotating olfactometer, the methylene chloride fraction was more attractive. Tests involving the methylene chloride–water interface (an emulsion of the two partitioned layers) with and without a standard attractant NuLure, showed the emulsion layer to be significantly more attractive than the other fractions or NuLure. In outdoor cage olfactometer assays of methylene chloride and water fractions, activity was greatest in the methylene chloride fraction. The results suggests that volatile semiochemicals from this nonhost plant are attractive to mated female Oriental fruit flies. The results are discussed in relation to the chemical ecology of *B. dorsalis* and the potential use of this nonhost plant for detection and control of female Oriental fruit flies in the field.

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INTRODUCTION

Dacine fruit flies from the family Tephritidae are a diverse group of more than 700 described species whose larvae infest many types of fleshy fruits found in tropical and subtropical regions (Metcalf, 1990). One polyphagous species, the Oriental fruit fly, *Bactrocera dorsalis* Hendel, is a serious pest of fruits and vegetables throughout the Asian Subcontinent and Pacific Rim countries including Hawaii, where the fly is established. The pest has been reported to attack over 173 different varieties of fruit and vegetables (Metcalf and Metcalf, 1992) and is considered a serious quarantine pest. Semiochemicals are involved in most current detection, control, and eradication technologies developed for tephritid fruit fly pests throughout the world (Jang and Light, 1996). They remain an important component of control programs, where the fly exists, and of detection programs, in areas where the fly does not exist but may become established.

The chemical ecology of these flies is complex, with flies responding behaviorally to both sex pheromones and various host and nonhost plant kairomones (for many monophagous as well as polyphagous species). The response of flies to semiochemicals has fascinated researchers since the observations of Howlett (1912) that oil of citronella (a nonhost) was attractive to males of two *Dacus* (*Bactrocera*) species. Currently, methyl eugenol, a potent male attractant first discovered by Howlett (1915) in oil of citronella, and various hydrolyzed protein products (e.g., NuLure), thought to be general food-type attractants for males and females of many tephritid species (Jang and Light, 1996), are used routinely for detection and/or control of Oriental fruit fly. While the potency of methyl eugenol as a male lure is well demonstrated, no comparable lure for females has yet been developed. Semiochemical attractants derived from nonhost plants have been reported for male *B. dorsalis* (primarily methyl eugenol) (Mitchell, 1965; Kawano et al., 1968; Fletcher et al., 1975; Tan, 1983). Jacobson et al. (1976) reported that asarylaldehyde, a distillate component from Indian calamus root oil, was attractive to female Oriental fruit flies. The need for a female-specific attractant for Oriental fruit fly as well as many other tephritid species has been regarded as a high priority in many fruit fly control programs for years (Jang and Light, 1996). Most studies looking for female attractants have focused primarily on host plants as a source of attractants (Chiu, 1990; Jang and Light, 1991; Light and Jang, 1996).

Stark (1995), studying the nocturnal behavior of tephritid fruit flies and their parasitoids in papaya-growing regions on the island of Kauai, reported a unique behavioral observation of Oriental fruit fly females in and around the

hedgerow plant panax, *Polyscias guifoylei* (Bull), bordering papaya fields in a commercial growing area of Moloa'a, Kauai. Female flies were observed leaving host plants (papaya) as dusk approached and landing on the undersides of panax leaves in the upper canopy, where they remained until dawn. Males followed the females, and, in some instances, were observed mating in the panax hedge. These observations were contrary to an earlier study by Stark et al. (1994) in commercial guava-growing regions on Kauai where Oriental fruit fly males and females were observed remaining to roost and mate in guava foliage throughout the night.

Based on the unique responses of females and males to the panax leaves reported by Stark (1995), we were interested in determining if volatile semiochemicals attractive to female Oriental fruit flies might exist in leaves of panax. This study reports on laboratory and outdoor olfactometer results showing the attraction of females to whole leaves and panax extracts. We discuss these results in regards to the usefulness of controlling fruit flies and the importance of studying nonhost as well as host plants in the chemical ecology of tephritid species.

METHODS AND MATERIALS

Insects. Adult flies used in this study were obtained as pupae from the mass-rearing unit at the USDA-ARS, Tropical Fruit & Vegetable Research Laboratory in Honolulu, Hawaii. Larvae were reared on a standard wheat, sugar, yeast diet (Tanaka et al., 1969). Pupae were shipped by air to Hilo where they were placed into 30-cm × 30-cm × 30-cm cubical aluminum screen cages containing sugar, water, and hydrolyzed protein. Flies were held at 24°C, 60–80% relative humidity, 12L:12D photoperiod until use. At least 24 hr prior to testing, cages of flies were placed in a 5°C walk-in refrigerator to immobilize them. Flies were separated by sex and placed into groups of either 25 or 50 males or females and placed in plastic containers (11.5 cm diameter × 7.5 cm deep) with nylon mesh covers containing sugar, water, and hydrolyzed protein. They were returned to the warmer temperature room (24°C) and held until use. Flies were approximately 9–11 days old when tested and presumed to be mated (ca. >95% of females from mixed cages are mated by day 7). For studies involving virgin females, flies were sexed within two days of emergence from pupae and held in groups of 50 females as above.

Leaves and Leaf Extracts. Mature undamaged leaves from panax plants, *Polyscias guilfoylei* (Bull) [L. H. Bailey], were taken from hedgerows bordering commercial papaya fields in the area of Moloa'a, Kauai, as described by Stark (1995). Leaves were placed in plastic bags and immediately shipped or hand-carried by air to Hilo. Bags of unused leaves were held in a refrigerator until

used. Prior to use, they were gently washed of all external debris with water and allowed to air dry at room temperature.

Extracts of panax were made by blending leaves in a methylene chloride–water (1 : 1) emulsion at a ratio of one part panax to two parts of the methylene chloride–water mixture (w/w) in an explosion-proof laboratory blender (Waring). A similar extraction was carried out using a hexane–water (1 : 1) partition. The resulting homogenates were strained through several layers of cheesecloth to remove particulate matter. The strained liquid was placed into several large glass separatory funnels (500 ml) and allowed to partition overnight (12–18 hr) under refrigeration. The following morning, the solvent layer (methylene chloride or hexane), a solvent–water interface layer (methylene chloride extract only), and the water layer were decanted off and placed in glass bottles. The five layers from the two extractions [CH_2Cl_2 layer, water layer from CH_2Cl_2–water partition, CH_2Cl_2–water emulsion (interface), hexane layer, and water layer from hexane–water partition] were kept refrigerated until used.

Laboratory and Outdoor Cage Bioassays. Tests of attractancy of panax leaves and extracts to flies were carried out in three different behavioral arenas. The first, a glass/metal laboratory flight tunnel consisted of a 0.9-m × 0.9-m × 2.8-m rectangular glass arena containing inlet and exit fans at the ends of the chamber, which produced a laminar flow of air (Jang and Light, 1991; Jang et al., 1994). Whole leaves (ca. 400 g) were placed in all-glass containers containing inlet and outlet ports (Jang and Light, 1991). The inlet port was connected to a tank of clean, breathing-quality compressed air, and the outlet port connected via Teflon tubing to the flight tunnel. Headspace odors from the leaves were swept from the container via the tubing into yellow plastic spheres hung inside the flight tunnel. Odors exited from small holes in the yellow plastic spheres. Exit flow rate into the spheres was 100 ml/min. Spheres were coated with Tanglefoot to trap alighting flies. A second sphere emitting only clean air served as a control.

Flight-tunnel tests of the various fractions were carried out using small invaginated glass McPhail traps in to which solvent or water fractions (or solvent or water controls) were placed. Approximately 5 ml of the fraction to be tested was added to 10 ml of water with two drops of Tween 20 added as a surfactant. Each test of whole leaves or extracts consisted of two-choice preference assays (two yellow balls or two McPhail traps) comparing an odor/fraction vs. a control or head-to-head comparisons of fractions. For each assay, 50 males and 50 females were released from the downwind end of the flight tunnel and allowed to respond freely for 2 hr. At the end of each test, trapped flies were counted, remaining flies removed, and the flight tunnel cleaned. All assays were run between 13:00 and 16:00 hr at a temperature of 26–28°C, under fluorescent lights (2000 lux) (Jang et al., 1994).

A laboratory multiple-trap rotating cage olfactometer described by Jang and Nishijima (1990) was used to compare different extracts in competitive tests. The olfactometer consisted of a 75-cm × 75-cm × 80-cm rectangular screened enclosure containing a 6-arm rotating hub. Glass McPhail traps or triangular Jackson traps containing individual fractions were hung on opposite arms of the rotating hub. Solvent or water layers of extract from ground panax leaves, solvent, or water controls, and, in some tests, NuLure (9% NuLure + 5% borax) (Miller Chemical Co., Hanover, Pennsylvania) were placed either in the water of the McPhail traps containing surfactant or directly onto a cotton wick suspended inside the Jackson traps. The hub was electrically rotated during a 2-hr assay period at a speed of 120 revolutions/hr. Fifty flies of each sex were released inside the cage and allowed to choose freely among the different extracts. Tests were run between 13:00 and 16:00 hr at 26–28°C under fluorescent lights (ca. 2000 lux). At the end of the test period, entrapped flies were removed and counted.

A larger-scale outdoor covered cage olfactometer employing the same principles as the indoor unit was used to confirm the laboratory findings. The outdoor olfactometer consisted of a 3-m × 3-m × 2.5-m rectangular wood-framed screen cage (screen on all four sides and the top) with a corrugated metal A-frame roof and wood floor. A rotating hub with arms approximately 62 cm long was hung from the center of the cage approximately 1.8 m from the floor. The outer arms of the motorized hub unit rotated at a rate of 90 rotations/hr. Extracts were placed in small glass McPhail traps as previously described. Approximately 900 flies of each sex were placed in the outdoor cage. Tests were conducted between 13:00 and 16:00 hr under ambient outside conditions (usually 23–28°C) and only natural (indirect) light was used. At the end of the test, flies were removed and counted.

Data Analysis. Results of the two-choice flight tunnel tests were compared using Student's *t*-test on SAS version 6.04 (Proc TTEST) (SAS Institute, 1990). Multiple-choice test results were analyzed using ANOVA, and means compared using the Tukey's studentized range (HSD) test (Proc GLM, SAS version 6.04) (SAS Institute, 1990). All analyses of significance were made at the $P < 0.05$ level of significance or lower.

RESULTS

Flight-Tunnel Assays. Female Oriental fruit flies were attracted to the odor of freshly picked panax leaves in laboratory flight-tunnel assays. Initial tests using 50 of each sex resulted in ca. 24% of released flies eventually being trapped (24 of 100) (Table 1). In these tests, 75% (18 of 24) of the total flies

TABLE 1. ATTRACTION OF ORIENTAL FRUIT FLY TO YELLOW SPHERES EMITTING HEADSPACE VOLATILES OF WHOLE PANAX LEAVES IN LABORATORY FLIGHT TUNNEL[a]

Treatment (50 males + 50 females)	N	Female capture (mean ± SEM)	Male capture (mean ± SEM)	Total capture (mean ± SEM)
Whole panax leaves vs. air	3	15 ± 2.6 a	4.3 ± 0.9 a	19.3 ± 3.2 a
	3	3.3 ± 0.3 b	1.7 ± 1.7 a	5 ± 2 b
Total		18.3	6.0	24.3

[a]Means followed by different letters within a column are significantly different at $P < 0.05$; t test (SAS, 1990).

captured were females, and 79% (15 of 19) of the flies attracted to panax odors were females.

When the water layer of the methylene chloride–water partition was compared with a water only control, the water layer captured significantly more females ($P < 0.01$) than water only (Table 2). Ninety-three percent of the mean number of flies (22 of 23.7) captured in McPhail traps containing the water layer were females. Tests of the methylene chloride-soluble layer against methylene chloride controls (both having a layer of water/surfactant above the fraction in the McPhail trap, see Methods and Materials) in the flight tunnel also showed a significantly greater ($P < 0.01$) capture with the methylene chloride layer than with the methylene chloride control (Table 2). In these tests, greater than 99% of the mean of total flies (22.4 of 22.5) captured in the methylene chloride layer were females. Ninety-nine percent of the mean of total flies captured in the test (24.5 of 24.7) were females. When the methylene chloride soluble layer was compared directly with the water layer, significantly more flies (80% or mean 29 of a mean total of 36.1) were attracted to the trap containing the methylene chloride layer. Ninety-three percent of the mean number of flies (27 of 29) captured in the methylene chloride layer were females (Table 2).

Virgin females with fully developed ovaries were tested to determine if the attraction of females was specific for mated females. Response of virgin females to the methylene chloride fraction (mean of 4.5 flies) was not significantly different from the corresponding methylene chloride control (mean of 1.67 flies) when tested in McPhail traps containing water and surfactant in the flight tunnel. Mean response was significantly lower ($P < 0.05$) compared to mated females of the same age.

Assays of the two layers from a hexane–water partition of ground leaves

TABLE 2. ATTRACTION OF ORIENTAL FRUIT FLIES TO FRACTIONS FROM CH_2Cl_2–WATER PARTITION OF PANAX LEAVES IN LABORATORY FLIGHT TUNNEL[a]

Treatment	N	Female capture (mean ± SEM)	Male capture (mean ± SEM)	Total capture (mean ± SEM)
Water layer of CH_2Cl_2:H_2O partition	5	22 ± 2.1 a	1.7 ± 0.8 a	23.7 ± 2.8
vs.				
Water control	5	0.1 ± 0.1b	0 ± 0 b	0.1 ± 0.1 b
Total		22.1	1.7	23.8
Methylene chloride layer of CH_2Cl_2:H_2O partition	9	22.4 ± 1.1 a	0.1 ± 0.1 a	22.5 ± 1.1 a
vs.				
Methylene chloride control	9	2.1 ± 0.4 b	0.1 ± 0.1 a	2.2 ± 0.4 b
Total		24.5	0.2	24.7
Methylene chloride layer of CH_2Cl_2:H_2O partition	7	27 ± 2.2 a	2 ± 1.8 a	29 ± 3.7 a
vs.				
Water layer of CH_2Cl_2:H_2O partition	7	4.8 ± 1.2 b	2.3 ± 1.5 a	7.1 ± 1.9 b
Total		31.8	4.3	36.1

[a]Layers (and their controls) were tested in McPhail-type traps; 50 males and 50 females released for each replication. Means followed by different letters within a column for each test group are significantly different at $P < 0.05$; t test (SAS, 1990).

showed no significant differences in attraction of females to either fraction (Table 3). This was in contrast to assays of the two layers from the methylene chloride–water partition. When the methylene chloride layer was tested against the hexane layer, flies (primarily females) were significantly more attracted to the methylene chloride layer (Table 3). Neither the hexane nor the methylene chloride solvent alone was attractive to Oriental fruit flies.

Olfactometer Assays. Competitive tests of both methylene chloride and water layers and their corresponding controls were conducted in an indoor rotating cage olfactometer. We also tested the methylene chloride–water interface-layer, an amorphous emulsion layer containing a mixture of the two separate layers as well as a small amount of particulate matter (Table 4, A). Interestingly, the interface layer caught significantly more ($P < 0.05$) flies than either the methylene chloride layer or the water layer. Both layers, however, caught a greater number of flies than controls. Ninety-six percent of the mean number

TABLE 3. RESPONSE OF ORIENTAL FRUIT FLIES TO FRACTIONS FROM $CH_2Cl_2 : H_2O$ PARTITION OR Hexane : H_2O PARTITION OF PANAX LEAVES IN LABORATORY FLIGHT TUNNEL[a]

Treatment	N	Female capture (mean ± SEM)	Male capture (mean ± SEM)	Total capture (mean ± SEM)
Hexane layer of $C_6 : H_2O$ partition	4	8.8 ± 2.5 a	1.7 ± 1.7 a	10.5 ± 4.1 a
vs.				
Water layer of $C_6 : H_2O$ partition	4	9.5 ± 2.1a	5.2 ± 4.9 a	14.7 ± 6.9 a
Total		18.3	6.9	25.2
Methylene chloride layer of $CH_2Cl_2 : H_2O$ partition	5	18.8 ± 2.6 a	0.2 ± 0.2 a	19 ± 2.8 a
vs.				
Hexane layer of $C_6 : H_2O$ partition	5	5.8 ± 1.7 b	0.2 ± 0.2 a	6 ± 1.7 b
Total		24.6	0.4	25

[a]Layers were tested in McPhail-type traps; 50 males and 50 females released for each replication. Means followed by different letters within a column for each test group are significantly different at $P < 0.05$; t test (SAS, 1990).

of flies captured (17 of 17.7) in the methylene chloride layer were females. Eighty-eight percent of the mean total flies captured (28.1 of 31.6) in all traps were females. In additional tests, which included the protein hydrolysate NuLure, the interface layer was significantly more attractive to females than any of the other fractions tested (Table 4, B). Both NuLure and the methylene chloride layer were not significantly different from water only (control). The interface layer caught 100% females. Males were significantly more attracted to NuLure than to any of the other treatments. Total fly capture was over 46% of the total flies released.

Flies tested in the outdoor covered olfactometer with methylene chloride and water-soluble fractions confirmed laboratory studies (Table 5). Significantly more flies were caught in the traps containing the methylene chloride layer than in the water layer. All flies captured in the methylene chloride layer were females.

DISCUSSION

The results of the study, confirmed by both laboratory and outdoor assays, suggest that volatile compounds from leaves of the hedgerow plant panax are

TABLE 4. COMPARATIVE ATTRACTION OF ORIENTAL FRUIT FLY TO LAYERS OF METHYLENE CHLORIDE–WATER PARTITION OF PANAX LEAVES IN INDOOR ROTATING OLFACTOMETER[a]

Treatment	N	Female capture (mean ± SEM)	Male capture (mean ± SEM)	Total capture (mean ± SEM)
Part A				
Water layer of $CH_2Cl_2:H_2O$ partition	8	2.7 ± 0.9 bc	1.8 ± 0.7 a	4.5 ± 1.1 b
Methylene chloride control	8	1.6 ± 0.9 c	0.2 ± 0.2 a	1.8 ± 0.9 c
Methylene chloride layer of $CH_2Cl_2:H_2O$ partition	8	6.6 ± 1.5 b	0.5 ± 0.3 a	7.1 ± 1.5 b
Water control	8	0.2 ± 0.2 c	0.3 ± 0.2 a	0.5 ± 0.3 c
Middle interface layer of $CH_2Cl_2:H_2O$ partition	8	17 ± 1.5 a	0.7 ± 0.4 a	17.7 ± 1.3 a
Total		28.1	3.3	31.6
Part B				
Middle interface layer of $CH_2Cl_2:H_2O$ partition	3	27.7 ± 3.1 a	0 ± 0 b	27.7 ± 3.1 a
NuLure	3	4.2 ± 0.7 b	6.3 ± 0.9 a	10.5 ± 1.5 b
Water control	3	2.0 ± 1.1 b	2.7 ± 1.3 b	4.7 ± 2.5 b
Methylene chloride control	3	3.7 ± 2.2 b	0 ± 0 b	3.7 ± 2.2 b
Total		37.6	9.0	46.6

[a] Layers were tested in McPhail-type traps; 50 males and 50 females per replication. Means followed by different letters within a column for each test group are significantly different at $P < 0.05$; Tukey's studentized range test (SAS, 1990).

attractive to mated female Oriental fruit flies. Tests of the layers of a methylene chloride–water partition confirmed that the active principle most likely resides in the methylene chloride fraction. We believe that the initial partition assays in the flight tunnel, which showed some attraction of females to the water-soluble portion of the extract (Table 2), can be explained by the intermediate polarity of methylene chloride (e.g., the water layer likely contains a small amount of methylene chloride). Head-to-head tests clearly show the methylene

TABLE 5. COMPARATIVE ATTRACTANCY OF ORIENTAL FRUIT FLY TO METHYLENE CHLORIDE–WATER PARTITION OF PANAX LEAVES IN OUTDOOR ROTATING OLFACTOMETER[a]

Treatment	N	Female capture (mean ± SEM)	Male capture (mean ± SEM)	Total capture (mean ± SEM)
Methylene chloride layer of $CH_2Cl_2:H_2O$ partition	5	67.2 ± 1.9 a	0 ± 0 b	67.2 ± 19.1 a
Methylene chloride control	5	0.6 ± 0.4 b	0.2 ± 0.2 ab	0.8 ± 0.4 b
Water control	5	5.2 ± 2.7 b	1.0 ± 0.8 ab	6.2 ± 3.3 b
Water layer of $CH_2Cl_2:H_2O$ partition	5	25.6 ± 9.4 ab	2.6 ± 0.9 a	28.2 ± 9.2 ab
Total		98.6	3.8	102.4

[a]Layers were tested in McPhail-type traps. Means followed by different letters within a column are significantly different at $P < 0.05$; Tukey's studentized range test (SAS, 1990).

chloride layer to be more attractive than the water layer. We believe that the strong attraction of the methylene chloride–water interface layer to flies can be explained in a similar way. The extract was partitioned for 24 hr or less before the extracts were separated. Allowing the emulsion to separate for several days largely reduces the volume (and activity) of the interface layer. An alternative explanation is that attractive components present in both the water layer and the methylene chloride layer are present in the emulsion.

We were perplexed as to how the methylene chloride-soluble fraction could be so attractive to females in the glass McPhail traps where the methylene chloride layer actually lay below the water/surfactant added to each trap to capture the flies. We believe that the water/surfactant emulsion actually helps in the controlled release of the active constituents from the methylene chloride solvent. Nigg et al. (1994) reported a similar phenomena in studying components from host plants attractive to Caribbean fruit fly, *Anastrepha suspensa*. They hypothesized that attractive components from leaf surfaces wet with dew may actually improve the attraction of Caribbean fruit fly to leaf volatiles over dry leaf surfaces. Response of flies to the methylene chloride layer without water in McPhail traps was low. We ascribe this to the repellent effect of many solvents in tephritid fruit fly olfactory assays. Results of assays in which solvent extract was placed directly on cotton wicks indicated that females were more attracted to the solvent–water–surfactant in the McPhail traps.

Although the precise role of panax in the chemical ecology of the Oriental fruit fly is not known, the study by Stark et al. (1994) and Stark (1995) and the results of this one demonstrate the need to study carefully the chemical ecology of polyphagus tephritid species, especially in the search for new and improved attractants. Metcalf (1990) cites the paper by Howlett (1912), who reported that oil of citronella was attractive to males of two species of *Dacus*, as a landmark observation in the chemical ecology of insects and, in particular, the dacine fruit flies. Since that time, the active ingredient from oil of citronella, methyl eugenol (Howlett, 1915), has been found in other nonhost plants as well (Mitchell, 1965; Kawano et al., 1968; Fletcher et al., 1975; Tan, 1983). Thus, the discovery of semiochemicals from nonhost plants attractive to females although surprising, should not be unexpected. Many plant volatiles are more or less ubiquitous in various host as well as nonhost plants and provide insects with a plethora of semiochemicals in their environment. Plant odors such as common "green leaf" volatiles (GLVs) present in leaves have been shown to modulate or enhance tephritid behavior, while other semiochemicals, such as the odor of ripening fruit, serve as primary kairomones (Light and Jang, 1996).

This paper is one of the few reports of a female-specific attractant derived from a nonhost plant for this species. Jacobson et al. (1976) reported that asarylaldehyde, a component of Indian calamus rootoil, was attractive to male and female oriental fruit flies in outdoor cage bioassays. The components in panax, however, are responsible for a female-specific attraction. The apparent preference of mated females for panax over other vegetation in the area is particularly interesting. Response of virgin females to leaf extracts was low.

Of particular interest for this species is the apparent plasticity in behavioral repertoires exhibited by flies inhabiting different ecological niches in or around host material. The Oriental fruit fly does not appear to migrate from commercial guava orchards (Stark et al., 1994), roosting (and mating) instead among the dense foliage of the guava trees throughout the night. In contrast, the vegetation in commercial papaya is less dense, and Stark (1995) initially hypothesized that movement from the commercial papaya to the panax was in response to the lack of roosting sites in the papaya. Stark (1995) reported observing females leaving the papaya fields and finding females in panax, apparently preferring the panax to other hedgerow plants in the area such as wiliwili, *Erythrina tahitensis*. Males followed females and were sometimes observed mating in the panax.

The attraction of mated females over virgin females to panax is a mystery. Stark (1995) did not identify the mating status of observed flies, but observed mating in the panax hedge in some instances. Host as well as nonhost kairomones from leaves, bark, and stems may act as "co-active attractants" (Light and Jang, 1996), which may increase the attractancy of a primary semiochemical (e.g., pheromone) and/or serve as "alightment-landing stimuli" for rendezvous sites and roosting. Thus, volatile semiochemicals from panax may elicit some

yet unidentified behavior specific to mated females. The precise role is at present unclear.

The potential of a female-specific attractant for the Oriental fruit fly is an exciting discovery and suggests the potential for the development of female lures. Extracts from panax may also selectively be attractive to other fruit fly species, and these are currently being tested. Further behavioral observations on the chemical ecology of polyphagus tephritid species and their parasitoids will likely bring new insight to the role of semiochemicals in their behavior and possibly lead to discoveries useful in detection, control, and eradication of these pests.

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